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Probing lower(most) mantle anisotropy using SKS-SKKS splitting discrepancies: New constraints on deep Earth dynamics

Maureen Long
Department of Geology and Geophysics, Yale University, New Haven, CT, USA (maureen.long@yale.edu)

Observations of seismic anisotropy in the upper mantle from shear wave splitting and surface wave analysis are abundant and represent the best constraints available on patterns of upper mantle flow. In contrast, our understanding of flow patterns in the deeper part of the mantle is relatively poor. Robust observations of seismic anisotropy in the lowermost mantle have been made, but the mechanism which generates anisotropy in the D” layer is not well understood. This stems in part from weaker observational constraints on the strength and geometry of lowermost mantle anisotropy, which in turn is due to the limited raypath coverage associated with shear waves that propagate (nearly) horizontally through the lowermost mantle. A different type of observation that can shed light on anisotropic structure in the lower mantle is the differential splitting of SKS and SKKS waves from the same event-station pair. Global studies of SKS-SKKS splitting discrepancies have demonstrated that in ~95% of cases, measured SKS and SKKS splitting parameters agree within measurement errors. In a few regions, however, SKS and SKKS arrivals from the same event exhibit significantly different splitting behavior. Because SKS and SKKS have very similar raypaths in the upper mantle but sample different regions of the lower mantle, SKS-SKKS splitting discrepancies are attributed to anisotropic structure in the deep mantle far from the receiver. Here I report observations of strongly discrepant SKS-SKKS splitting observed at broadband stations in western Mexico and California. In particular, strong SKKS splitting with fast polarization directions near ~ 60º and delay times up to ~ 3 s is observed for a group of raypaths that sample a region of the D" layer beneath the eastern Pacific Ocean. A comparison of SKKS splitting with SKS splitting observed from the same events, as well as with SKS splitting observed at a variety of backazimuths at each station, suggests that the anomalous anisotropic structure is in the lowermost mantle. My preferred model for the unusual anisotropic geometry in this region is large shear deformation in D" at the edge of a region where slab material impinges upon the core-mantle boundary, resulting in lattice preferred orientation of lower mantle minerals. With the increasing availability of data from dense broadband seismic arrays, differential SKS-SKKS splitting should become an increasingly powerful technique to characterize anisotropy in the lower mantle. I discuss several avenues for further progress in characterizing anisotropy in the deep mantle using SKS-SKKS splitting discrepancies, including the consideration of finite-frequency wave propagation effects.